(12) **UK Patent Application** (19) **GB** (11) **2 303 754** (13) **A**

(21) Application No 9004278.9

(22) Date of Filing 26.02.1990

(30) Priority Data
(31) 8904884.7 (32) 03.03.1989 (33) GB

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(51) INT CL⁶
G01S 7/35 13/32

(52) UK CL (Edition O)
H4D DRPR D265 D376
U1S S1839

(56) Documents Cited
GB 2202329 A   GB 1504118 A   GB 1246142 A
GB 1140590 A   US 4219812 A

(58) Field of Search
UK CL (Edition K) H4D DRPB DRPE DRPR DSPB DSPS
DSPX
INT CL⁵ G01S
Online : WPI, CLAIMS, INSPEC

(54) **Ranging systems**

(57) A continuous wave ranging system, comprises a modulator 2 for modulating an r.f. carrier wave in accordance with a pseudo random code, a transmitting antenna 5 for radiating the modulated signal towards a target, a receiving antenna 6 and receiver 7 for detecting the signal reflected back from the target. A correlator 8 correlates the reflected signal with the transmitted code, with a selected phase shift corresponding to the current range gate to be tested, whereby the range of the target from the system may be determined. A store 12 contains a plurality of different pseudo random codes, and selector means 13 is arranged to supply to the modulator 2 and to the correlator 8 a code from the store 12 whose breakthrough sidelobe characteristics (Figs.4-6) are suitable for the next range gate or gates to be tested. By choice of the code independence upon range (Fig.7), the effects of the underlobes are eliminated (Fig.8).
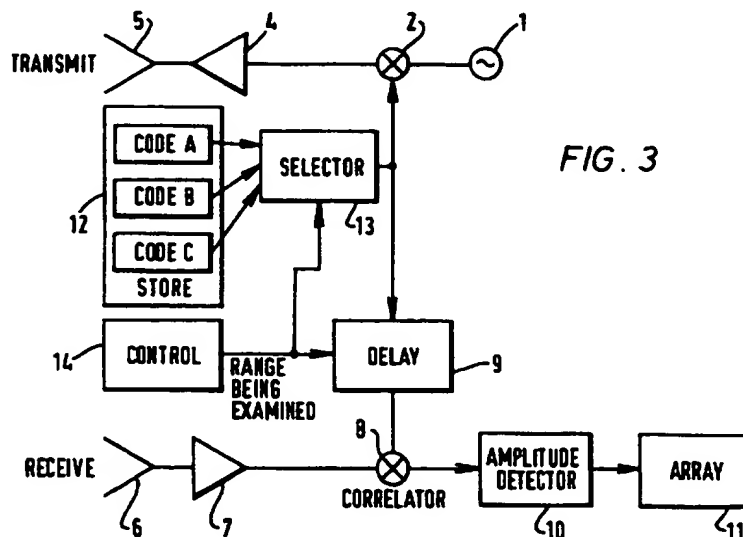
FIG. 3

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FIG. 1

FIG. 2

FIG. 3

FIG.4

CODE A

FIG.5

CODE B

FIG.6

CODE C

FIG.7

| B | B | B | B | C | C | C | C | C | C | C | A | A | A | A |

FIG.8
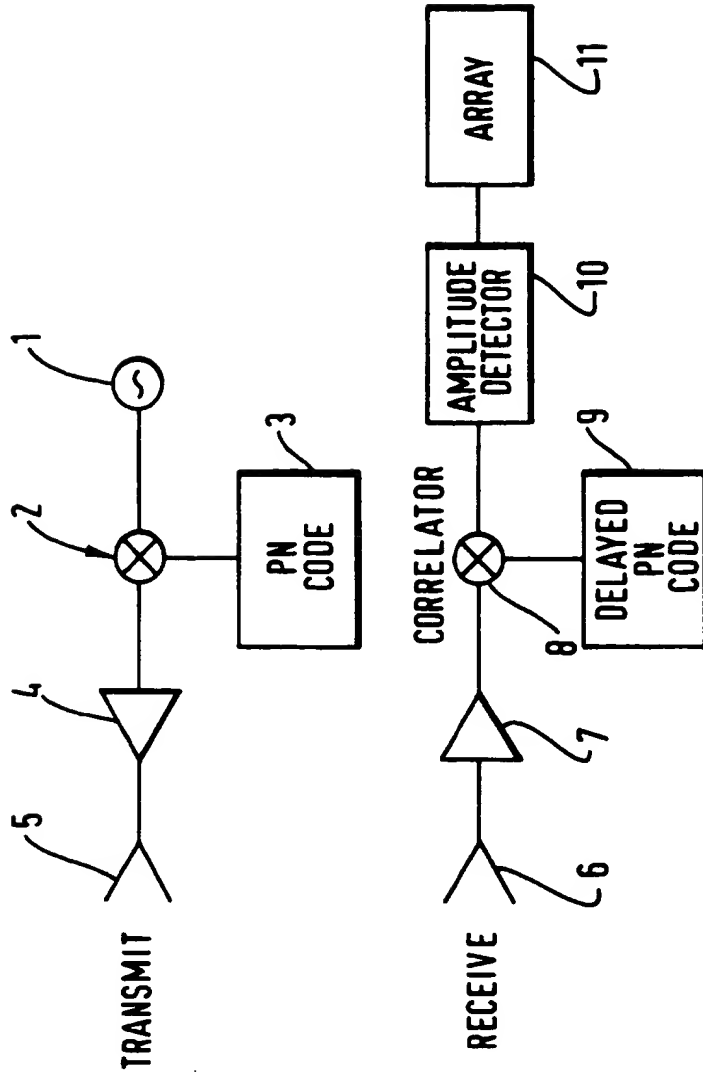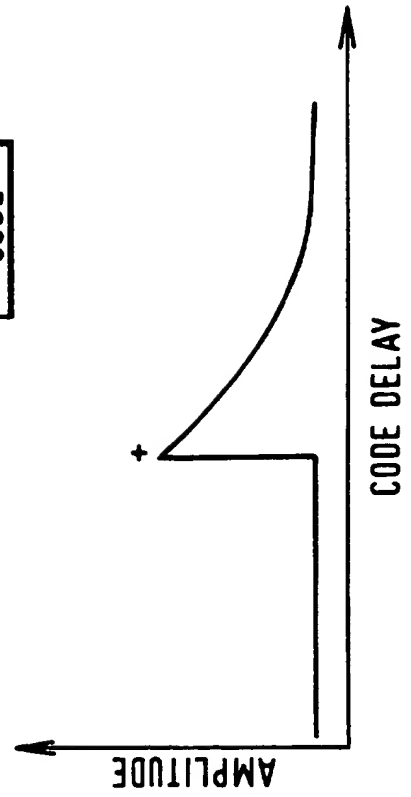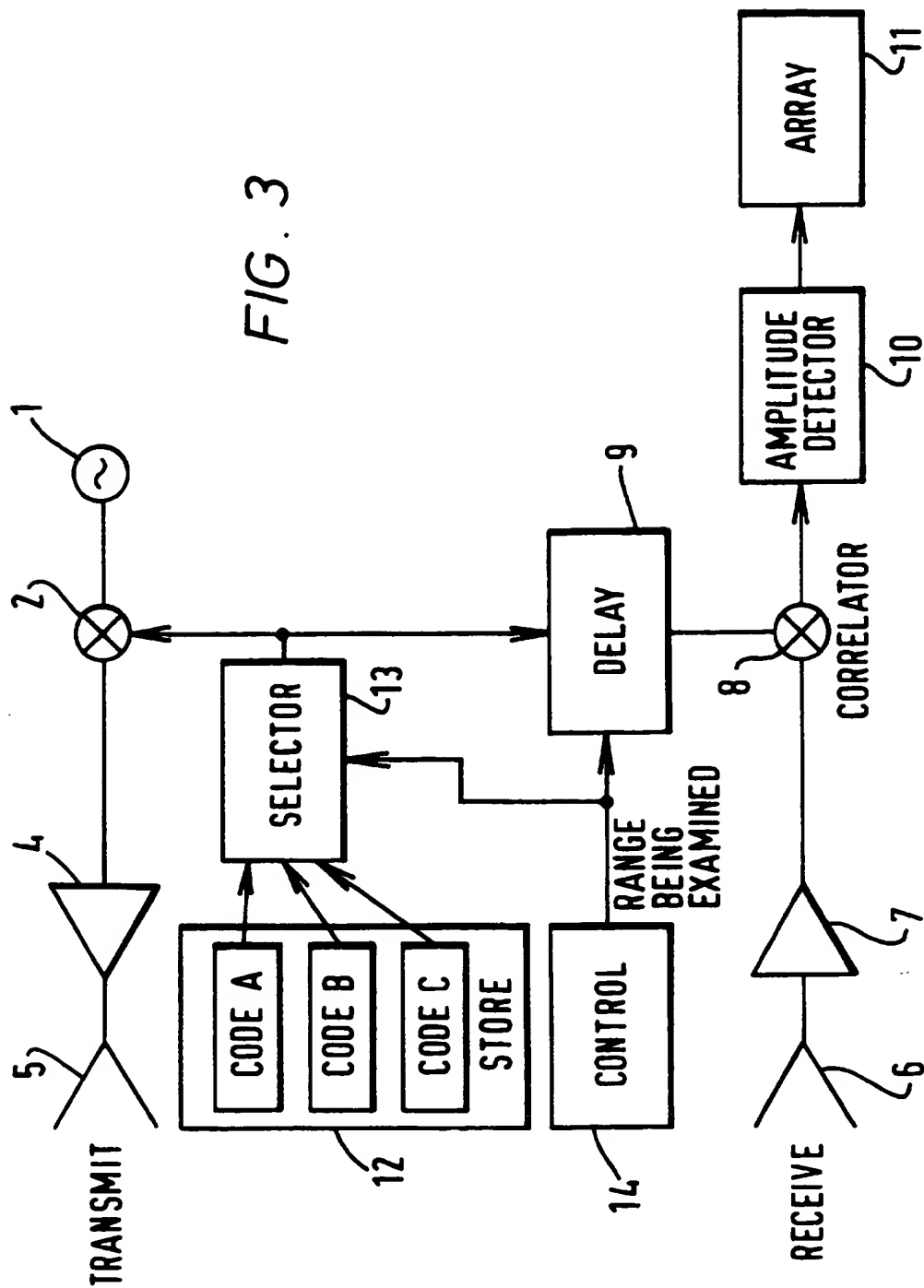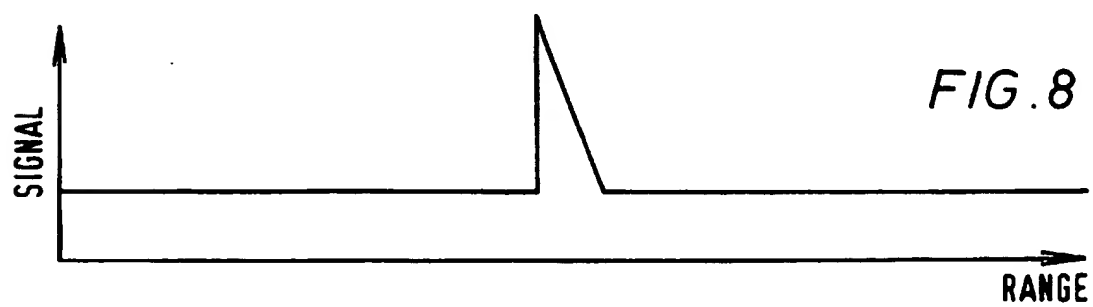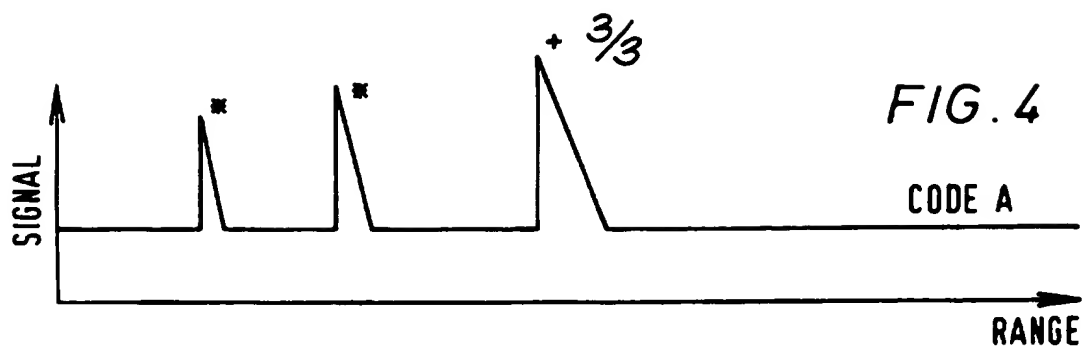
RANGING SYSTEMS

This invention relates to a continuous wave ranging system and, in one aspect, to an aircraft radar altimeter system.

Such systems usually comprise a means of microwave transmission upon which some form of coding has been added, and antenna for directing the energy to the target, an antenna for receiving the returned energy and, after amplification, a means of determining the amount of delay that has occurred on the signal, and hence the range 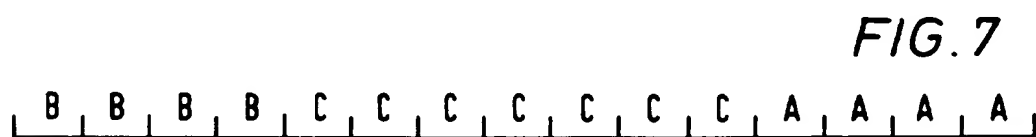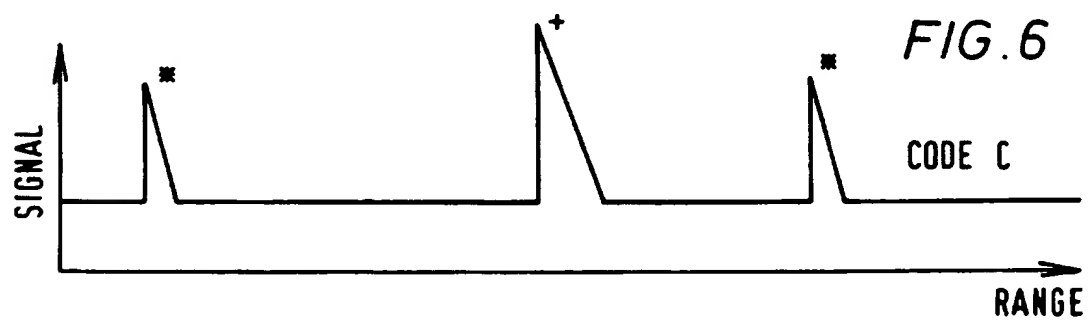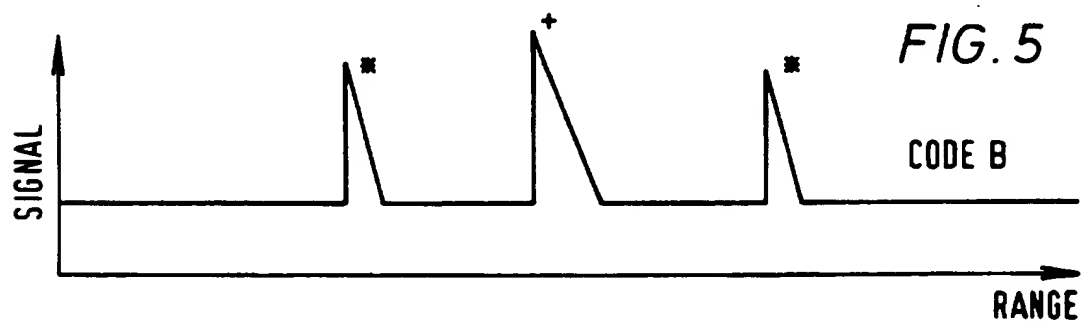of the target. The coding on the transmission had in the past been pulse or frequency modulation, but more recently phase modulation from a pseudo-random code has been used. This form of modulation has the property of producing a noise-like transmitted spectrum which is difficult to detect and hence finds applications where covertness is of importance. Covertness can be enhanced by reducing the transmitted power such that the returned signal is just sufficient for ranging measurement.

In such phase-modulated systems, the received

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signal is correlated with a delayed version of the transmitted code, the delay being gradually increased in steps, and samples of the output of the correlator are detected and stored in an array. From this stored data, the delay, and hence the range, where the received signal return occurs can be found. A typical system is shown in Figure 1 and comprises:- a transmitter including an r.f. signal generator 1; a modulation 2 for modulating the r.f. signal in accordance with a pseudo-random code 3; a transmitter amplifier 4 and a transmitting antenna 5. The receiver includes a receiving antenna 6; a receiver amplifier 7; a correlator 8 for correlating the received signal with a delayed version of the transmitted code corresponding to the range being examined; an amplitude detector 10 and a memory array 11.

The data for such a system is shown in Figure 2, the code delay corresponding to range.

The system shown in Figure 3 uses the same reference numbers as in Figure 1 for corresponding portions of the system. The system shown in Figure 3 differs from that in Figure 1 in respect of the correlation system utilised. In this system, the

received signal is correlated with a selected phase shift on delay 9 corresponding to the range being tested. However, the system also includes a store 12 containing a plurality of different pseudo-random codes and a selector 13 which supplies a suitable code from the store 12 to the modulator 2 and the delay 9 and hence to the correlator 8. The suitable code is selected on the basis of the sidelobe characteristics to be switchable for the range being tested and the selector 12 and delay 9 are both controlled by a controller 14.

In a direct sequence spread spectrum ranging system, correlation sidelobes can appear at any range, due either to the transmitter to receiver breakthrough or to wanted signals. These sidelobe positions can be shown to be related to the position of the signal (breakthrough or otherwise) causing the sidelobe, and the particular pseudo-random code sequence in use. By careful selection of the code sequence, it is possible to achieve a signal to sidelobe performance which allows the sidelobes of wanted signals to be disregarded. However, since the breakthrough signal is usually much greater than any wanted signal, a problem is evident when considering wanted signal to breakthrough sidelobe

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levels. Since the breakthrough signal position is constant, it has been found possible for any given code sequence to determine the position of the resulting breakthrough sidelobes.

Accordingly, the invention provides a continuous wave ranging system, comprising a modulator for modulating an r.f. carrier wave in accordance with a pseudo-random code, a transmitting antenna for radiating the modulated signal towards a target, a receiving antenna an receiver for detecting the signal reflected back from the target, a correlator for correlating the reflected signal with the transmitted code with a selected phase shift corresponding to the current range gate to be tested, whereby the range of the target from the system may be determined, a store containing a plurality of different pseudo-random codes, and selector means arranged to supply to the modulator and to the correlator a code from the store whose sidelobe characteristics are suitable for the next range gate or gates to be tested.

The pseudo-random code used in the invention is preferably a maximal length code, a sequence of numbers generated by a shift register with certain feedbacks on

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it. For the system of the present invention, a code length of 2047 digits is preferred.

The present invention will now be described, by way of example, with reference to the accompanying drawings in which:-

Figure 3 is a schematic view of a system according to one embodiment of the present invention, and

Figures 4 to 8 illustrate in simplified diagrammatic form plots of signals utilised in the system.

Figures 4, 5 and 6 show in greatly simplified diagrammatic form plots of signal level against examined range cell obtained by correlation for three different pseudo-random codes. The peaks marked with asterisks are the breakthrough sidelobes, while the peak marked (+) is the true signal. Since the position of the breakthrough sidelobes may be determined for any given pseudo random code in any given system, in one aspect of the invention, a range scanning algorithm is arrange to select the use of codes A, B and C to eliminate the effect of the breakthrough sidelobes. The code is

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changed only when necessary to minimise the effects of transients on changing code and the delay necessary to allow for the round trip time of the new code to the ground and back. In practice, the code is transmitted repeatedly, and for each sequence received, the code supplied for correlation is either maintained at the same delay for several sequences of code, to filter out the effect of any variations and thereby increase accuracy before stepping onto the next range gate, or the phase shift is incremented for each correlation.

Figure 7 shows in simplified form the sequence of codes selected to avoid the breakthrough sidelobes appearing in the diagrams of Figures 4, 5 and 6. Selection of code B avoids the first sidelobes appearing in Figures 4 and 6, while changing them to code C avoids the second sidelobe in Figure 4 under and the first sidelobe in Figure 5. Finally, changing to code A avoids the final sidelobes in Figures 5 and 6. The resultant response in idealised diagrammatic form is shown in Figure 7.

The code maps themselves are easily implemented by the use of arrays of Boolean variables indexed by range. Each Boolean entry need only signify the suitability of

a particular code for operation in the indexed range. In order to minimise the storage requirements for the resultant code maps, it is desirable that each array element in the map should cover a significant proportion of the entire range, for example 1/20th. Thus each map need only contain 20 values.

In order to minimise the number of code changes made, the scanning algorithm will sometimes need to look ahead when faced with a choice of two or more suitable codes. This look ahead will need to take into account the required scanning order, but if an increasing range scanner is used, then the operation merely involves looking forward through the maps of each suitable code and choosing the one which remains suitable for the longest range. Should two or more codes satisfy this requirement, then the choice is unimportant.

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CLAIMS

1.   A continuous wave ranging system, comprising a modulator for modulating an r.f. carrier wave in accordance with a pseudo random code, a transmitting antenna for radiating the modulated signal towards a target, a receiving antenna and receiver for detecting the signal reflected back from the target, a correlator for correlating the reflected signal with the transmitted code with a selected phase shift corresponding to the current range gate to be tested, whereby the range of the target from the system may be determined, a store containing a plurality of different pseudo random codes, and selector means arranged to supply to the modulator and to the correlator a code from the store whose sidelobe characteristics are suitable for the next range gate or gates to be tested.

2.   A system as claimed in claim 1, wherein a plurality of codes re-selected from the store and used in a sequence which substantially eliminates the effect of breakthrough sidelobes.

3.   A system as claimed in claim 1 or 2, wherein the codes are selected on the basis of suitability for

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use in future envisaged ranges.

4.   A   system as claimed in claim 3,   wherein   the range   is   scanned increasingly, the codes suitable   for the longest ranges can be selected.

5.   A   system as claimed in claim 3 or 4,   wherein the or   each- code is selected to reduce the   number   of code changes required when scanning different ranges.

6.   A   continuous wave system ,   substantially   as described with reference to the drawings.

Amendments to the claims have been filed as follows

1.   A continuous wave ranging system, comprising a modulator for modulating an r.f. carrier wave in accordance with a pseudo random code, a transmitting antenna for radiating the modulated signal towards a target, a receiving antenna and receiver for detecting a signal reflected back from the target, a correlator for correlating the reflected signal with the transmitted code with a selected phase shift corresponding to the current range gate to be tested, whereby the range of the target from the system may be determined, a store containing a plurality of different pseudo random codes, and selector means arranged to supply to the modulator and to the correlator a code selected from said store, which code does not provide a breakthrough sidelobe within the next range gate to be tested.

2.   A system as claimed in claim 1, wherein a plurality of codes are selected from the store and used in a sequence which substantially eliminates the effect of breakthrough sidelobes.

3.   A system as claimed in claim 1 or 2, wherein the codes are selected on a basis of suitability for use

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with a plurality of range gates.

4.   A   system as claimed in claim 3,   wherein   the range is scanned increasingly and the codes suitable for the largest number of range gates are selected.

5.   A   system as claimed in claim 3 or 4,   wherein the or   each code is selected to minimise the number of code changes required when scanning different ranges.

6.   A   continuous   wave system,   substantially   as described   with   reference   to   figures 3 to 8   of   the drawings.

Patents Act 1977
Examiner's report to the Comptroller under
Section 17 (The Search Report)

Application number

9004278

Relevant Technical fields	Search Examiner
(i) UK Cl (Edition K) H4D: DRPB, DRPE, DRPR, DSPS, DSPB, DSPX	G A McLEAN
(ii) Int Cl (Edition 5) G01S	

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASES: WPI, CLAIMS, INSPEC

Date of Search

23 AUGUST 1990

Documents considered relevant following a search in respect of claims

1 - 6

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
Y	GB 2,202,329 A (BAE) - especially claim 1, page 6	1, 3, 4
Y	GB 1,504,118 A (SIEMENS) - whole document	"
Y	GB 1,246,142 A (ISE) - especially lines 12 - 14, page 1; lines 24 - 34, page 2; lines 27 - 36, page 3; lines 16 - 49, page 9	"
Y	GB 1,140,590 (STC) - especially lines 24 - 27, page 1; line 24, page 3 - line 56, page 4	"
X, Y	US 4,219,812 (USA) - especially lines 37 - 53, column 1; line 67, column 2 - line 10, column 3; line 54, column 3 - line 18, column 4	"

SF2(p)

7/3/06, EAST Version: 2.0.3.0